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A neo-institutional perspective of supply chains and energy security: Bioenergy in the UK

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HIGHLIGHTS

- Proposes a neo-institutional approach to analyse bioenergy supply chains.
- Analysis of UK bioenergy illustrates problems posed for energy security.
- Institutional processes and carriers enable creation and diffusion of new rules.
- Conflicts over institutional rules complicate bioenergy development.
- Conflicts about bioenergy are conveyed by institutional processes and carriers.

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ABSTRACT

The paper argues that potential insights into the emergence of more sustainable energy systems relevant to the promotion of energy security may be obtained from adopting neo-institutional theory. The paper suggests that a more comprehensive analytical approach is available compared with previous contributions, which tend to focus on institutions as governmental agencies and 'regulative rules'. The paper thus outlines an approach to analysing institutional rules, carriers, processes and mechanisms, which is illustrated with reference to the emerging 'organisational field' of bioenergy for the generation of heat and power in the UK. The paper discusses implications of the above for understanding and improving energy security. The conclusion outlines the contours of future work on the prospects and difficulties associated with fully embedding the emerging organisational field of bioenergy and sustainable energy systems, and reflects on what might be gained from an application of neo-institutional theory.

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1. Introduction

In many countries energy policy is widely accepted as having to address both climate change and energy security requirements, and that doing so requires a transformation in the way energy is supplied and consumed. However energy security is a term that is used to mean quite different things. It is used to refer to national 'sovereignty' over energy resources, to 'resilience' of infrastructure and its design, to 'robustness' of energy systems [1], and to 'the continuity of energy supplies relative to demand' [2]. The concept of energy security understood as the need to 'secure' new energy supplies or to industrialise even renewable sources has been argued to detract from the pursuit of energy efficiency in favour of 'keeping the lights on' and growing exports [3]. The plasticity of the term is exemplified by UK policy. Here, UK governments have defined energy security in relation to: (a). physical security, which entails the avoidance of 'involuntary physical interruptions to consumption of energy (i.e. the lights going out or gas supplies being cut off)'; (b). price security, which requires the avoidance of 'unnecessary price spikes due to supply/demand imbalances or poor market operation'; and (c). geopolitical security, which in connection with energy supply needs means 'avoiding undue reliance on specific nations so as to maintain maximum degrees of freedom in foreign policy' [4]. These are central to UK energy policy, as evidenced by successive iterations of government policy regarding a low carbon future [5]. The government expects that '[m]ore diverse sources of electricity will improve energy security and reduce exposure to fossil fuel imports and price spikes' [6]. These are anticipated to include power generated from sustainable biomass.

Bioenergy (in the form of gas and especially as liquids) rely on a controversial set of thermochemical or biochemical process technologies for converting feedstock inputs into energy, and has been

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promoted as a solution to the need for efficient, low carbon energy generation for providing heating and cooling, electricity, and fuel for transportation. In many other countries, as well as the UK, the case has been put, though not without dispute, for such technologies to be capable of meeting concerns regarding the independence and security of energy supply, climate change mitigation, the development of a green economy, and economic development more generally. In 1990 electricity generation from bioenergy was 0.6 TWh, rising to 3.9 TWh in 2000, with 5.8 TWh and 9.9 TWh representing the corresponding totals for renewable energy generation from all renewable sources in each year [7]. In 2012 total electricity generation from renewable sources was approximately 41 TWh (12 GW capacity), of which bioenergy generation accounted for around 15 TWh (3 GW capacity) [8]. The UK Bioenergy Strategy (2012) states that biomass could account for 20–40 TWh or 5–11% of delivered energy in power generation in 2020, 12% of primary energy in 2050, and 30 to 35 TWh, and about 6% of the total energy needed for heating (compared with about 1% currently) [9]. It has been predicted that there will be a shift from bioenergy being a relatively small contributor to heat and power generation, fed by domestic supplies (primarily of waste), to bioenergy making larger contribution to heat and power generation, relying on imported feedstock (mainly of wood) [10]. Inputs into bioenergy systems have been the subject of great hype concerning, for example, the efficient growth and energy potential of certain biocrops, whilst there has been a great deal of concern regarding their environmental sustainability, as well as the amount of agricultural land devoted to growing crops for fuel instead of food, particularly in less developed countries.

The objectives of the paper are: to identify factors affecting the growth of generation of heat and electric power from biomass sources in the UK, which may affect the ability of bioenergy to contribute to climate change and energy security goals; and to demonstrate the benefit of a neo-institutional approach for understanding the key issues. The research questions are: (i). What institutional factors are implicated with development of the UK bioenergy field? (ii). What are the implications of these institutional factors for the bioenergy supply chain? (iii). What are the implications of the answers to the first two questions for the growth of heat and electricity generation related to bioenergy and for energy security? A fundamental issue relates to the shaping of supply chains for bioenergy, the effectiveness of which may promote the establishment and growth of a sustainable energy subsystem. Analysis of pertinent factors should take into account the policies, know-how and interactions of state and other stakeholders relevant to investment in producing biomass feedstock, conversion technologies and energy production facilities [11], as well as to the societal 'impact' of bioenergy [12]. It also pertains to the coordination of the supply chain and should take account differences between the management of the supply chain for bioenergy and that of 'traditional' supply chain management [13]. These critical issues for supply chain management of bioenergy have been neglected by supply chain research, which has tended to focus on technologies for producing energy from biomass sources and the potential biomass and not on fundamental but essentially non-technical issues [11].

The paper adopts a neo-institutional perspective, drawing on the contribution to organisational studies and sociology of researchers such as Scott [14], Jepperson [15] and Powell and DiMaggio [16]. This, it is argued, may enable richer analysis of the various actors and the nature of institutions implicated in developing bioenergy. It involves a wider range of actors than would typically feature in analysis of sustainable energy supply chains. This includes identification and analysis of the potential for and implications of institutional transformation connected with political, environmental, economic and social practices and assumptions, implicated with the emergence and diffusion of more sustainable energy systems. The perspective helps to explain the emergence of bioenergy systems by bridging phenomena, which tend to be served poorly by discipline-based accounts. Thus it addresses both supply and demand factors, public policies and operational practices, and issues to do with scale, diffusion and learning. To accomplish this requires a multi-disciplinary view, with insights being drawn from the sociology of organisations, innovation, business strategy and political economy, which have all contributed to neo-institutional theory. Such an approach may illuminate the relation between policy-making objectives for energy security and climate change mitigation and what may appear as more operational concerns regarding bioenergy supply chain management and logistics.

Transcending existing literature the paper considers how the development of a bioenergy 'field' is implicated (partly through institutional entrepreneurship [17]) in the variable establishment of a range of regulatory, normative and cultural-cognitive institutional rules, which govern practice in the focal area of inquiry, whilst being open to recreation or supersession. However, rules are not all. So, the paper considers connections among such rules (or institutional 'pillars') and various mechanisms, processes [14] and carriers [18] associated with institutionalisation (or non-institutionalisation).

The paper proceeds as follows. Section 2 outlines the main ways in which the institutionalisation of bioenergy systems has been conceived, and offers a critique of extant research, which informs the work of the paper. Section 3 addresses the limitations of previous research by outlining what a more complete neo-institutional analysis would look like. In short, a more comprehensive treatment should analyse the pillars, carriers, mechanisms and processes of institutionalisation identified by Scott and others. Section 4 discusses the implications of the paper for understanding issues connected with energy security and managing supply chains, following which Section 5 concludes the paper by drawing together the strands of the preceding sections and suggesting future research directions.

2. Previous research on the institutionalisation of bioenergy systems

Previous research may be categorised according to the principal focus of the research involved and the concept of institution employed. These are outlined below.

(a) Institutions as entities

As in studies on other topics, research on the emergence of bioenergy systems is concerned with institutions as organisational entities. For example, Adkins et al.'s study [19] compares alternative designs for cookstoves used in educational establishments (schools). Further, Tripathi et al. [20] researches and compares gasifier-based biomass, coal and liquid petroleum gas technical options available for cooking in institutions in India, where 'institution' refers to hostel, hotels, schools and community centres providing meals for groups of over 25 people.

(b) Institutions as rules

There are a number of studies that involve analysis of institutions, conceived as rules [21,22]. One example is that of Åkerman et al., who examine the role of rules and practice in the emergence of large-scale technological systems connected with pulp and paper in Finland [21]. They explain the emergence of small-scale bioenergy in Finland in relation to the diffusion of expert knowledge around the boundary object of young forests (in essence this shows how new practices may be 'carried' and thus institutionalised).

Another is work by Söderberg, which analyses the institutional factors and conditions conducive to integration across sectors and the effective development of bioenergy policy in Sweden. Institutions according to Söderberg should be seen formal and informal rules that guide behaviour [23].

(c) Institutional challenges/capacity

A number of contributions focus on the challenges or barriers to be overcome in order for energy production from biomass sources to be realised more widely [24–26]. Costello and Finnell [24] identify regulatory, financial, infrastructural and perceptual barriers to the development of a market for biomass power technologies. McCormick [11,26] focuses on barriers to the wider adoption of bioenergy in the European Union, which include economic and market factors, 'know how', supply chain coordination, and 'institutional capacity'. Institutional capacity is understood in terms of the learning capacity and experience of established or new actors (such as farmers), which may be enhanced by local pilot projects to grow crops for bioenergy production as exemplified by initiatives within the EU – at Enköping, Sweden, for example.

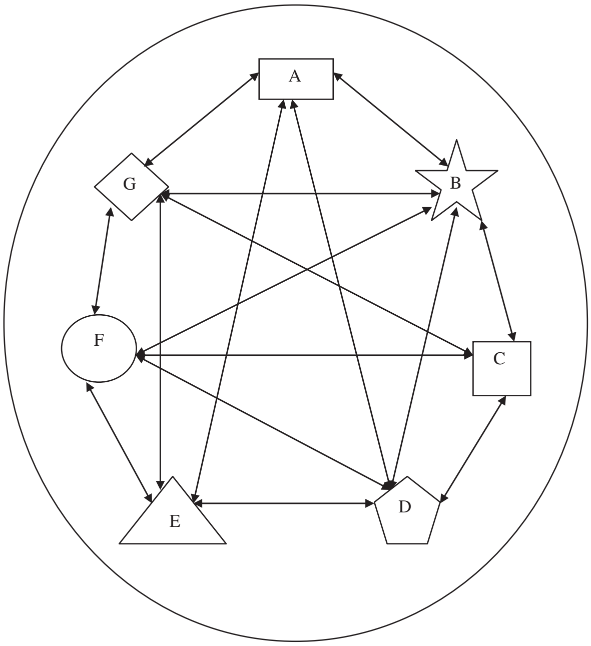
(d) Institutional economics

Another stream of research relevant to the concerns of this paper invokes institutional economics [27,28]. Such work identifies non-technical barriers and drivers of market growth, aiming to analyse the likely extent of vertical integration in the market for biomass pellets, stoves and so on, and the implications of this for future investment and competition in this and for other rival heating technologies. It is informed by contributions from transactions costs theory [29–31] and information economics [32]. Transaction costs approaches have in general been concerned with the efficiency of alternative modes of governance – referred to as markets, hierarchies and intermediate hybrid forms – through which contracting is more or less efficiently done, work which offers a theoretical framework with which to understand the boundaries of the firm, and what it will 'make' internally or 'buy' in.

2.1. Critique

A number of observations may be made regarding extant research on bioenergy relevant to concerns about what an institutional perspective may offer. Firstly, there is a focus on governmental and policy-related factors, which undervalues attention to multi actor relations, activities, interests and values. Secondly, the preoccupation of some contributions with regulation or legislation, which are of course likely to be important drivers of institutionalisation and institutional change, runs the risk of omitting or underplaying other kinds of (normative, cultural or cognitive) institutional rules. In this regard, the paper argues that analysis of rules (institutional pillars) is insufficient and that there are other aspects of institutions that have thus far been neglected (implicit references in prior work to institutional carriers and processes notwithstanding [21,22]), such as carriers and processes, which enable institutions to be created, undone or maintained. Thirdly, the focus on growth of the markets, informed by a certain reading of contributions to institutional economics, may be too narrow, thus again failing to capture the range of factors and interactions necessary to account for institutionalisation (or lack thereof). The paper does not employ a neo-classically informed institutional economics approach to relevant issues such as contracting but instead adopts the sociological variant of neo-institutionalism, in which such phenomena are the product of and subject to a wider range actors and factors than ones ordinarily understood to be connected with the 'market'.

The concept of 'organisational field' is one which encompasses a broader array of actors than 'industry' or 'market', taking into account the full range of actors which 'in the aggregate, constitute a recognized area of institutional life' relevant to supply and consumption of similar goods and services and the main issues connected thereto [16]. As shown in Fig. 1, this organisational field includes those who supply or use heat or electricity from biomass sources, as well as (UK and overseas) suppliers and consumers of bioenergy feedstock inputs, including farmers. It also includes national and international government and regulatory agencies, whose actions, and the credibility of whose actions may affect the actions of financial organisations considering investment in bioenergy as well as its diffusion. Further, one may identify communities and residents, who may increasingly play a dual role in bioenergy production and consumption, local authorities, and NGOs. A number of non-governmental actors may be influential in articulating demand or supply practices related to bioenergy, thus conferring legitimacy on the emerging organisational field. Understanding the bioenergy 'field' in this way allows for a greater range of factors to be accounted for related to the emergence of bioenergy, the organisational forms, practices and values of the actors, and the processes which enable or inhibit wider institutionalisation, than if one merely relied on the narrower concept of 'industry' or 'supply chain'. (The kinds of supply chain activities that these actors may influence is indicated by Fig. 2). Based on examination of extant documentary sources, such as state policy documents, and industry and NGO reports, the paper characterises the emerging UK-related bioenergy organisational field and the institutional dynamics which affect its development, including



Key to actors in the bioenergy organisational field:

A = Suppliers of heat, electricity, transport biofuel; B = Users of bioenergy end products; C = Farmers, other suppliers of feedstock inputs; D = Governmental and regulatory agencies; E = Articulators of supply/demand (e.g. community organisations, residents groups, local councils, chambers of commerce, NGOs); F = Science and research organisations; G = Financial organisations and investors

Fig. 1. Actors and selected interactions in the organisational field of bioenergy.

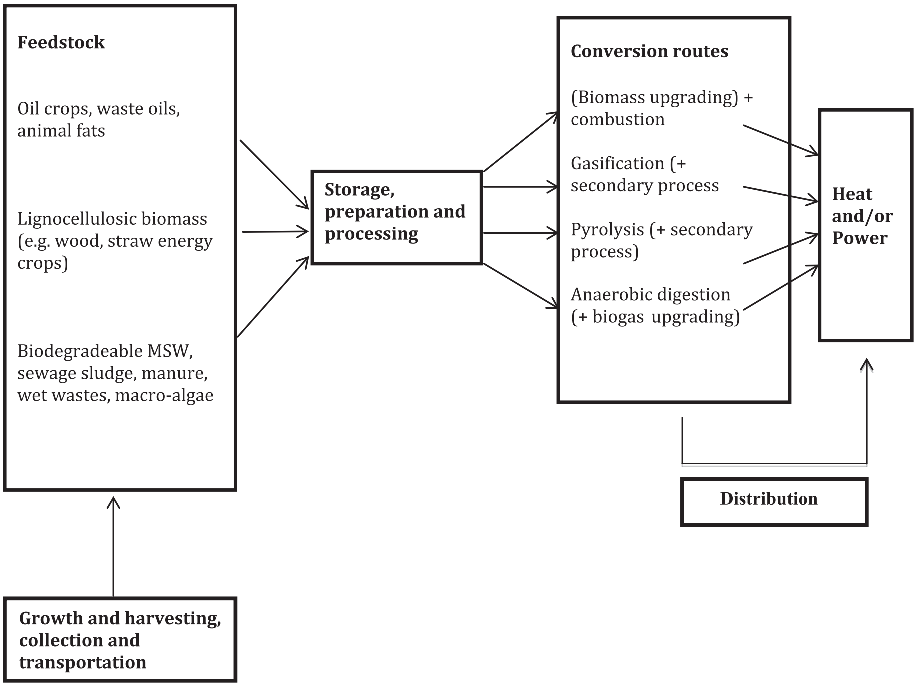

Feedstock
Oil crops, waste oils, animal fats
Lignocellulosic biomass (e.g. wood, straw energy crops)
Biodegradeable MSW, sewage sludge, manure, wet wastes, macro-algae
Storage, preparation and processing
Conversion routes
(Biomass upgrading) + combustion
Gasification (+ secondary process
Pyrolysis (+ secondary process)
Anaerobic digestion (+ biogas upgrading)
Heat and/or Power
Distribution
Growth and harvesting, collection and transportation

Fig. 2. Supply chain for heat and electricity from biomass feedstock.

interactions among supply chains, demand, governance and investment. Section 3 highlights interactions among institutional carriers and different kinds of institutional rules implicated in the historical development of the UK bioenergy organisational field, while illustrating the proposed neo-institutional framework.

3. Neo-institutional analysis of UK bioenergy 1989–2013

The section is informed by the contents of Table 1, which also provides orientation regarding the type of data that researchers conducting neo-institutional analysis should look for. It considers in turn four carriers of institutions: routines, relational systems, symbolic carriers and artefacts [14]. These are analytically distinguishable from but are inter-related in practice with nascent or prevailing institutional rules and the mechanisms that ensure compliance with the rules. The mechanism of coercion ensures compliance with regulative rules; social obligation or (professional) pride elicits compliance with normative rules; and 'taken-for-grantedness' engenders compliance with cultural-cognitive rules [14]. An illustrative case study considers developments relevant to the organisational field of UK bioenergy and energy security. The account is presented broadly as unfolding in two distinct phases: phase 1 representing the initial emergence of 'modern bioenergy' between 1989 and 2003; and phase 2 representing the period since 2003, which is the year of enactment of the Sustainable Energy Act and the publication of the landmark White Paper 'Our Energy Future' [33], and more concerted and disputed attempts at institutionalisation.

The two phases of the case may be contrasted as follows. Phase I may be thought of as the 'birth' of modern bioenergy in the UK. Thus from a position of making a negligible contribution to electricity and heat generation, generation from bioenergy sources rose, partly as a result of the actions of generators established in the aftermath of deregulation of the gas and electricity markets, post-1989. At this time energy generation was seen in terms of large-scale infrastructure, and as an activity carried out by 'big' generators, in spite of the break-up of the state monopoly the Central Electricity Generating Board (CEGB). International agreements regarding combatting climate change were either in negotiation or had not sufficient 'grip' to influence investments and other actions towards the achievement of such ends. Further, at the beginning of the 1990s, environmental issues had not the salience with industry norm and practice shaping entities that they later did – indeed the trade association British Bioenergy was not formed until 1995. In relation to cultural awareness and perception, the green

Table 1
Institutional rules and carriers.

Carriers	Pillars		
	Regulative rules	Normative rules	Cultural-cognitive rules
Routines	Legislation and regulations affecting contracting, financing and operations	'How things *should* be done' (in accordance with professional norms or standards); Job tasks and roles	Scripts (guiding how things *are* done habitually)
Relational systems	Governance and coercive power structures	Normative authority systems (e.g. certification; good practice guidelines)	Identities structural isomorphism
Symbolic systems	Legislation, regulations, policies and targets with symbolic effects	Values expectations	Categories typifications mental models
Artefacts	Objects conforming to legal and regulatory requirements	Objects conforming to conventions and professional standards	Objects possessing cultural significance

movement in the UK grew on the back of increasing public popularity, most notably manifest in the significantly increased vote in the European elections of 1989 and the elections of MEPs in 1999. The green movement exploited concerns about and also played a key role in spreading the message regarding the dirtiness and injustice of biomass.

In phase II there was more concerted state and international level effort directed at climate change mitigation and adaptation, including the specification of targets for the reduction of greenhouse gas emissions and generation form renewable energy sources. In the UK these were supplemented with specific strategies and regulations for bioenergy and microgeneration, first emphasising electricity but later heat generation also. If phase I was 'birth', phase II may be thought of as the 'infancy' of bioenergy in the UK. Generation and generating capacity increased significantly in absolute terms and as a share of the respective national totals for heat and power but bioenergy continued to take faltering steps. In terms of UK field development it is interesting to note the formation during this period of the Renewable Energy Association in 2001, whilst British Biogen was wound up in 2006. Internationally, the European Biomass Association was formed in 1990 (and continues to operate), the Swedish Bioenergy Association was formed in 1980 and the World Bioenergy Association was founded in 2008. Widespread criticism and concerns about problems associated with bioenergy, and of government policy related to the field remained during this phase, expressed by green campaigners, local communities and industry protagonists.

3.1. Routines

With regard to routines a number of laws and state policies were central to the emergence of modern bioenergy in the UK in the 1980s and 1990s. Among these were privatisation of the state utility – the Central Electricity Generating Board – in 1989 and deregulation of the markets for electricity and gas. The Net Fossil Fuel Obligation was a provision of the Electricity Act (1989) and was the principal mechanism employed by government in the UK to stimulate growth of renewable energy during the 1990s (though nuclear power was the intended beneficiary), offering generators long-term contracts for electricity at fixed prices. Many large-scale plants for bioenergy production now in operation in the UK were contracted for under five 'orders' of the NFFO made in England and Wales between 1990 and 1998, three orders made in Scotland between 1994 and 1999, and two made in Northern Ireland between 1994 and 1996, during which time the price of electricity generated from renewable energy sources was reduced significantly [34,35]. The last of these contracts will receive financing until 2019 [36].

In the 2000s international commitments such as the ratified Kyoto protocol provided the context in which UK regulative rules affecting operational routines for bioenergy were made (see the discussion of symbolic carriers below). To stimulate progress against this target and others related to greenhouse gas emissions, measures such as the Renewables Obligation (RO), Renewables Obligation Certificates (ROCs) and Feed in Tariffs (FITs) were introduced. The Renewables Obligation (RO) aims to increase the share of electricity generation from renewable sources to 30% [37]. It requires electricity suppliers to increase the share of renewable energy sources in the electricity they supply or pay a penalty known as the 'buy-out price'. ROCs are issued by the Office of Gas and Electricity Markets (Ofgem) to electricity generators for eligible renewable electricity produced. Generators can sell these certificates to electricity suppliers or traders for a premium plus the wholesale price of electricity, and act as proof of compliance with the RO by suppliers. Feed in Tariffs (FITs), introduced in 2010, is a financial incentive for small-scale low-carbon electricity generation aimed mainly at households and small businesses. Bioenergy plant must comply with the EU Waste Incineration Directive of 2000 (among others such as the Large Combustion Plant Directive of 2001), which places restrictions on the type of biomass that can be used for energy production. Non-compliance may result in the plant in question losing its permit to operate or being subject to restrictions on its activities [38].

Cultural-cognitive rules include the form of contracting conventionally employed currently, which is a kind of script followed by suppliers, investors and financial organisations and others in organisational fields, that may need to be adapted for bioenergy, for which demand and supply are uncertain [39]. With regard to energy crops there is a difference between the time horizon of farmers who grow crops for sale on an annual basis and those firms requiring certainty of feedstock for bioenergy plant, for whom long-term contracts provide greater reassurance about supply and costs [40]. The International Energy Agency (IEA), a professional authority in the field, note a tendency for investors to prefer short payback periods of between 2 and 4 years, which is a rule of thumb that penalises conversion plants and technologies with high capital costs (large gas and coal plant having capital costs typically about 25% less than for large bioenergy plants). Moreover, SMEs investing in smaller bioenergy plant facilities face problems in obtaining financing from banks. This is due to a lack of understanding of the project risks and financing, and a lack of familiarity of banks and other would-be investors with the situation to be confronted. Transactions costs for the SME are thus increased [40].

Routinised practices for bioenergy conversion are critical to the economic and environmental performance of bioenergy value chains, as are those related to harvesting and transporting the feedstock from the field to the conversion site. Professional organisations continually advance recommendations for good practice regarding this (which is in itself a manifestation of the institutionalisation of their role). Thus the IEA recommends importation and embedding of operational concepts associated with other sectors is suggested, such as the practice of 'sequential harvesting' [40]. Also recommended by the IEA is the application of the concept of 'biorefineries', which may be capable of achieving economies of scope by enabling production of the widest range of products and chemicals from a multiplicity of different kinds of feedstock. Here the small scale and fragmentation of UK bioenergy plant is argued to be inhibitive, as is the emphasis placed on (i.e. the institutionalisation of) research on developing lignocellulosic-based feedstock systems [40]. The Environment Agency advises that the discovery, application and spread of 'best' and 'worst' practices significantly impacts on the GHG emissions savings obtainable from bioenergy compared with alternatives energy sources [41].

3.2. Relational systems

Policy-making initiatives have attempted to institutionalise new relational systems for promoting bioenergy. In the 2000s DEFRA set up the Biomass Energy Centre (in 2006, with the Forestry Commission) as a one stop contact point offering advice and information to woodland managers and owners, farmers, and the general public. However this was short-lived, following the recent cessation of funding for the Biomass Energy Centre, which means that its website can no longer take and respond to enquiries [42]. Relational systems in bioenergy production and consumption (as carriers of the normative pillar) are exemplified by novel though not yet widespread types of relationship among suppliers and users, such as the practice of developers engaging with residents in preparing plans for the siting of bioenergy plants. A common recommendation (of bodies such as the International Energy Agency and the IPCC) has been that bioenergy utilities should engage with stakeholders such as local residents and farmers, for example through shareholding or third party funding schemes [40,43]. A number of measures have been implemented to with a view to 'professionalising' bioenergy [34]. A Woodfuel Suppliers Group was set up in January 2011, administered by the trade association Con-For, to act as an umbrella body to 'build and improve capacity' in member firms. In addition woodfuel producers and end users have been able to study and learn from counterparts from Austria and Finland about improvements in supply chain practices, by going on tours, site visits and undertaking training relating to woodland management and boiler installation [34].

Cultural-cognitive rules may be 'carried' that compete with each other. For example, the lack of a hegemonic view of the benefits for environmental sustainability of bioenergy may be traced to the work and influence of separate conflicting 'dialogue networks': one involving a cluster of sceptical environmental NGOs and influential individuals, another more upbeat about such claims and comprising a range of industry and governmental organisations. Such relationships are viewable in joint publications such as the RSPB/Friends of the Earth and Greenpeace 'Dirtier than Coal' report of 2012, and the statement supporting the benefits to biodiversity of sustainably managed woodland, jointly signed by the Forestry Commission England, Greenpeace, Wildlife Trust, RSPB and Countryside Link in July 2009 [44,34]. The deeply polarised nature of debate is noted by a rival consortium of 25 policy-makers, firms and research organisations comprising the Energy Research Partnership (ERP) who bemoan that 'the potentially negative aspects of bio-fuels have been most widely reported. This in turn has made policy formulation extremely difficult and therefore impacts on market confidence.' [45] In their report the ERP refer to a paper in Science published in 2008, which they say is 'exemplary' but which also gives the polarisation a lifespan of at least five years [46].

3.3. Symbolic systems

In addition to those mentioned in Section 3.1 on the emergence of bioenergy in the 1990s, a raft of regulative rules in the form of legislation and policies have symbolised the intention of the state to further grow production of low carbon and renewable energy in the 2000s, in what has been referred to as the 'subsidy game' that will engender the required investment in bioenergy [47]. For example, at the EU level the member Heads of State approved an Energy Policy for Europe in March 2007 and the EU Renewable Energy Directive (RED) setting national targets to enable the achievement of the EU energy policy came into effect in 2009. RED stipulates that renewable energy sources should achieve a 20% share of overall EU energy consumption by 2020 and required national governments to devise and implement National Renewable Energy Plans [48]. Previously, EU policy featured specific but non-binding targets set in the Renewable Electricity Directive (2001) and the Bio-fuels Directive (2003) [49]. In the UK the target is that 15% of overall energy consumption should come from renewable energy sources by 2020 [48], compared with 1.3% achieved in 2005. These measures signal the intention to institutionalise renewable energy, including bioenergy. However, there is *prima facie* evidence of regulative rules being received negatively by investors. For example the EU Large Combustion Plant Directive appears to have led to the opt-out or closure of UK coal fired power stations for which co-firing or conversion to dedicated bioenergy was planned [50]. The impermanent and insubstantial nature of certain regulative measures may symbolise a lack of stability or confidence regarding bioenergy. One example concerns the Renewables Obligation, which will close to new generators in 2017. Only those in the scheme by then will continue to receive support until 2037. The English Woodland Grant Scheme (EWGS) is another example – the total value of the Woodfuel Woodland Improvement Grant package and associated support is low (£10 million) and the grant is available only for 30 months from Summer 2011 until 31 December 2013 [34].

An example of a categorisation that has been made holds that investors in small-scale bioenergy plant are often entrepreneurs in SMEs whom have limited technical skills and funding. This type of investor are claimed to have a tendency to purchase second-hand equipment requiring less technical sophistication for their maintenance but which may be relatively inefficient compared with more advanced alternatives [40]. There is a deeply entrenched set of differences over what bioenergy represents. There are commonly expressed beliefs about the potential implications of expanding bioenergy in the UK. For example, these include beliefs about the unsustainability of bioenergy, which is framed in terms of competition between energy crops (such as short rotation coppice and miscanthus) and food crops and resources such as water and land, as well their impact on biodiversity. Other widely held, institutionalised beliefs assert the low energy density of bioenergy as well as seeing the green credentials of burning biomass for energy as a 'myth' [51]. Sceptical categorisations of bioenergy apply more specifically to the co-firing of biomass with coal even among NGOs which accept that biomass will play a role in meeting climate change commitments and to the benefits of anaerobic digestion (as perceived by people living in rural areas and by farmers) [52]. More broadly, one may point to the perceptions of bioenergy held by a range of stakeholders, including those connected with views of its possible integration with the prevailing energy system. Seven 'waves' of the Department of Energy and Climate Change's public attitude survey have shown less support for bioenergy compared with other renewable energy technologies [53]. The overlay of the symbolic and the relational is illustrated by the observation that 'positive assessments' of bioenergy by local residents may be obtained when developers of bioenergy facilities institute more open approaches to engaging with residents and facilitating their early influence on related plans [54].

There are doubts about the suitability of a government policy toward bioenergy and energy security that relies on imports, with a number of influential actors offering their own suggestions for 'revising the policy framework' [55] or pinpointing what they see as deficiencies in the way aspects of the UK Bioenergy Strategy have been derived [44]. An example of the latter involves the argument that accounting principles underpinning the UK Bioenergy Strategy are flawed and the lack of clear sustainability standards and requirements [44,56,57].

3.4. Artefacts

Artefactual carriers include trees and bioenergy plants. An example concerns the public acceptance of plans to increase UK feedstock by means of tree felling, which carries with it concerns about spoiling the landscape and adverse impacts on wildlife and flora. As noted above energy crops are manifestations that may also convey pathways for development and the success of bioenergy, or harm associated with it. Environmentalists argue that bioenergy stations relying on imported feedstock embody an unsustainable approach to land and resource use, which results in deforestation in developing countries. From the perspective of potential investors it is argued that there are insufficient examples that could typify completed, dedicated, large-scale biomass electricity projects. Also symbolic are announcements such as RWE npower's declaration that it would not go ahead with plans to build two new large scale dedicated biomass power stations and would close down the 750 MW Drax power station, which was to be the subject of conversion to enable operation on biomass inputs instead of coal. Though it has since received a new lease of life with significant government funding, the announcement of the closure of Drax was reported at the time to be a 'blow' to the industry and 'welcome news to some green campaigners' worried about pollution among other things [58]. In either case such artefacts, and the stories concerning them, carry a (strong or weak) message to consumers, energy firms and others regarding the achievability and manner of bioenergy development.

4. Institutional processes and implications for energy security

The previous section described interacting institutional carriers and rules implicated in the emergence of the UK bioenergy organisational field. Fundamentally, the account paints a picture of limited institutionalisation. The initial phase – roughly covering the 1990s – saw investments stimulated by a limited range of regulatory mechanisms affecting the routine activities and disposition of investors (i.e. their beliefs about the meaning of government policies). The effect of other potentially institutionalising processes and carriers was relatively weak. Over the past decade or so a second phase has been marked by the introduction of myriad national and international instruments. Now UK national policy appears symbolic of a new emphasis on localised, smaller or converted plant. Compared with the 1990s UK bioenergy production has grown markedly but the field remains immature overall. This is due to the absence or poor diffusion of effective routines for contracting and financing for certain specific supply chain activities connected with harvesting, transportation and conversion of feedstocks, but also of novel approaches for managing stakeholder relationships, despite the manifold activities of professional bodies. The field remained highly contentious and subject to criticisms and symbolic interpretations 'carried' by NGOs and others, and by 'dirty' artefacts (i.e. bioenergy plants).

In relation to 'physical' energy security, as well as to exemplifying the significance of symbolic and artefactual institutional carriers, the ability of bioenergy to contribute to a decarbonised but reliable supply of heat and power for the UK is in doubt to the extent to which its claims to be renewable, sustainable or low carbon energy are questioned. This works against the legitimation and 'sedimentation' of bioenergy based on commonly shared precepts regarding what is to count as sustainable bioenergy, a matter that is complicated with different beliefs about what kind of bioenergy the state should support. An area that has seen partial convergence recently concerns scale. The view of environmental NGOs and bodies such as the Committee for Climate Change that diffusion of large-scale dedicated biomass plant is unfeasible or undesirable has informed the most recent policy for UK bioenergy, in which for power generation emphasis is placed on smaller-scale bioenergy plant, co-firing and 'coal replacement' [9]. From a neo-institutional perspective the strategic responses to this clear declaration of policy intent are of interest, for instance whether it is supported publically by green campaigners (regarding their beliefs about the credibility and effectiveness of government policy), by professional organisations (in terms of changes in emphasis regarding codes of practice, standards and definition and sharing of best practices), or by firms looking for reassurance about prospective investments in large-scale facilities. The example of RWE npower mentioned above indicates that a 'defiant' response rather than one of 'acquiescence' to an emerging field frame is likely [14,59].

Sustainability of feedstock remains another area of concern, both in relation to environmental and other impacts of supplying inputs to be converted in bioenergy plant but also with regard to the geopolitical dimension of energy security. One manifestation of this is domestic, with there being agreement among various actors that the UK lacks 'clear and consistent' binding sustainability criteria for to ensure that adverse impacts from sourcing of bioenergy inputs are minimised [10,44,50,60]. In relation to recent EU policy, on the manufacture of pellets from wood fibre from trees grown outside the EU, investors and suppliers are 'unsettled', not so much by the advent of proposed sustainability criteria per se but, it is claimed, by its unworkability in administrative terms, which would make it difficult for pellet importers to comply [50]. In particular the EU proposal is considered to impose certification on US growers not currently subject to formal certification routines, and who would resist it as external interference, with possibly damaging consequences for supply to the EU. This kind of objection could represent an attempt at strategic 'manipulation' of the rules of certification, or a more benign wish to negotiate a 'compromise' over regulative certification arrangements.

An aspect of institutional innovation concerns the impact of technology development on the way things get done. In this case it may in future be linked to the availability and pervasive application of carbon capture and storage technology at a scale suitable for optimising productivity in bioenergy facilities, without which the achievement of targets for bioenergy generation may be beyond reach. Moreover, the extent to which biomass facilities follow the practice of using 'the heat generated from electricity generation' may increase the energy conversion efficiency of plants, though it is noted that 'methodologies and tools' are required which 'allow savings (in relation to the reduction of greenhouse gas emissions) to be easily yet rigorously assessed' [41]. A key issue for neo-institutionalists (and others) concerns level of activity and analysis and whether and how the technical development and deployment of CCS gets bound by legislation and regulations at the national level, industry standards and intra-organisational manuals or scripts followed by staff.

With reference to price security, expansion of bioenergy in a manner that relies on mass importation runs the risk of the price of inputs and thus the price of power and heat delivered being inflated, in addition to potentially destroying the livelihoods and means of life of people in less developed countries. The development and spread of partnerships among farmers or woodland owners and bioenergy firms could be central to lowering the price of converting overseas land whilst managing this in a manner that is sensitive to the environmental consequences of doing so [43]. The neo-institutional perspective suggests that the articulation (or 'theorisation' and 'objectification') of such practices, and their popularisation, may be driven by professional bodies or associations to facilitate learning from exemplars [61]. However their effective adoption will likely depend on the capacity of individual organisations to absorb and 'habituate' them internally.

The organisational field is susceptible to shaping by apparently external material conditions in the wider economy and society. For example the unavailability of ships and port facilities suitably adapted for (multiple types of) bioenergy feedstock raises transport costs. Moreover, pelletisation is the only economically viable and established approach to 'densification', whereas other approaches like pyrolysis, hydrothermal upgrading and torrefaction are all in early stages of technical development [45]. Further, there appears to be a trade-off between the employment of such approaches to lower transportation costs as are available and protecting the usability of the feedstock during conversion [45]. These issues may be presented as phenomena external to the organisational field, to which participants (e.g. suppliers) are subject. However, it could also be argued that these factors are subject to being shaped by the institutionalised beliefs, norms and actions of field protagonists, some of whom might, for example, invest in R&D to improve feedstock transportation and conversion, vertically integrate, or adopt different heuristics regarding the aforementioned trade-offs. To the extent that this is so agents are capable of institutionally entrepreneurial activity.

5. Conclusion

There are multiple ways in which ‘energy security’ may be understood, which include ensuring that supplies are maintained relative to demand, subject to the maintenance of national sovereignty over energy supplies and energy price and geopolitical considerations. The paper argues that there is great potential for neo-institutional theory to be applied informatively at the ‘organisational field’ level to increase our understanding of the problematic emergence of bioenergy for electricity and heat generation, and its contribution to lowering carbon dioxide emissions from energy use and supply, as well as to improving energy security. The institutional development of modern UK bioenergy could be described as uneven and subject to competing framings, making the legitimacy of bioenergy at the field level elusive. In the 1990s and 2000s an industrial scale approach to bioenergy was preferred, reinforced by state targets and policies (regulative rules) relating to renewable energy, electricity and heat generation and climate change, against a background of a shortfall of domestic supplies relative to the ambitions being pursued. Yet a more limited role for new large-scale, dedicated bioenergy in power generation announced recently has symbolised a change in the rules of the game, creating instability whilst indicating the state’s preference for investment in non-dedicated bioenergy plants including the conversion of existing coal-fired plants and application of carbon capture and storage technology. Regulative rules and professional norms associated with the sourcing and transportation of possibly unsustainable inputs over long distances to conversion plants remain unclear and disputed. Guidelines for best practice and the adoption of novel roles by protagonists are manifestations of professionalisation of UK bioenergy, associated with its development and appearing as nascent but not fully embedded normative institutions; the best practices and roles remain the exceptions rather than the norms. Cultural-cognitive rules are implicated in ingrained beliefs underpinning widely held, competing views of how to account for (un)sustainability, the credibility and justification of government policy, the notion of ‘industrial’ bioenergy and, fundamentally, the categorisation of bioenergy as sustainable. The paper illustrated the conveyance of such rules by various institutional carriers. The question remains as to how the strategy based on non-dedicated bioenergy plants will accomplish the policy commitments and targets set, particularly with regard to electricity generation, considering the plant efficiency, supply, sustainability and socio-economic issues.

Having employed a descriptive approach illustrating the neo-institutional approach, the next step is perform a more exhaustive formal analysis. This could combine data gathered from archive and documentary sources, as relied upon here, with interviews, surveys or ethnography studies to capture various aspects of non(institutionalisation) related to the focal research questions (in this case connected with the factors underlying limited development of the modern UK bioenergy ‘field’ and implications for energy security). Such work would be wide-ranging; it would entail detailed scrutiny of the policy dimension to rule creation, entrepreneurial supply chain models and contracting, the work of professional associations and practices for ‘doing’ and learning about bioenergy, and identity formation and organisational forms adopted within the bioenergy organisational field, inter alia. It would benefit from analysis of discursive processes by which people derive meanings that make institutions appear solid – an avenue that the author has begun to explore [62]. Such a programme of work would likely require a multi-disciplinary perspective and be very demanding of resources. It could, however, generate original insights into a topic of great academic and practical significance.

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